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DEVELOPMENT OF ADJUSTABLE ELEVATOR FOR TRACTOR DRAWN POTATO DIGGER

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ABSTARCT

Potato is the major crop grown in the country. It is a rich source of carbohydrate, used all over the country. Potato is harvested when it attains the physiological maturity. Potato harvesting is a time consuming operation, due to its various activities taken place at the same time. There is different equipment of harvesting the potato, from the field. This equipment is tractor operated, animal drawn, or hand operated. Tractor operated potato digger cum elevator is mainly used for digging and exposing potato tubers, simultaneously. The digger was found to perform very well, under varying soil condition. A potato digger cum elevator was designed and constructed, which is capable of digging potato with a minimum of injury, working on the principle of digging and elevating the soil and potatoes, simultaneously. Because of the irregular shape of a potato, many of them impact with rods, side walls and solid colds, and jump out of the conveyor web inserted windrowing them in a row. Potato jumping and damage become excessive, when vertical oscillation is vigor. Extra labor is, therefore, required for manual picking. To rectify this problem of bouncing of tubers, on the conveyor the adjustable elevator is made, at which we can adjust the elevator height two different distinct were the tubers doesn't bounce on the elevator. It was observed that, at an elevated height of 40cm the implement is working more efficient rather than at another height, there was no damage, loss, bruising loss, cutting loss and also, there was no bouncing of the tubers on the elevator while digging. Actual field capacity is 0.30 – 040ha/h, Digging efficiency (%) 94 – 96, Cutting of tubers (%) 1.8, Field efficiency (%) 76.54.

KEYWORDS: A potato digger cum elevator was designed and constructed, used for digging and exposing potato tubers, simultaneously & there was no damage, loss, bruising loss, cutting loss and also

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INTRODUCTION

Potato harvesting is one of the most important operations, which have to be performed preciously, to have a good potato production. It has a direct effect on the potato bruising. Bruising has an essential effect on potato market. The mechanic bruising could happen, when the tractor wheels roll on the potato rows during harvesting.

Solanum Tuberosum L., potato derived from Spanish language "patata", is an ancient cultivated crop of South America of the 16th century, when Spaniard arrived and has been considered as one of the oldest tuber crop, brought under cultivation in all countries of the world. According to Hawke's, potato plant was taken to India, by

the British missionaries in the late 17th century and to China, a little earlier. Since then, potato has been cultivated through the country, as a vegetable crop. In India, potato is known by various names in different regions and in various languages, such as Alu in Bengali, potato in English, Aloo Batala in Gujarati, Aalu in Hindi, Urala Kizangu in Malyalam, Bilati Alu in Oria, Uruzhai Kilangu in Tamil, Bangaladumpa Aalugadda in Telugu etc. Potato is considered as one of the most important vegetable crops, supplying human with carbohydrate. It classifies as the first alternative, as the grain crops to solve the shortage of food in some countries.

Nutritive Value and Composition of Potato

Potato is a non-fibrous, non-cereal vegetable crop of both sub-tropical and temperate regions. It occupies the largest area, under any single vegetable crop in the world, and produces more food content per unit area, than cereals in a short time. In some respects, it excels cereals in nutritive value and palatability. Potato tuber chiefly comprises water (75%-80%), carbohydrates (16%-20%), crude protein (2.5%-3.0%), fat (0.1%) and 1% minerals like calcium, copper, iron, magnesium, phosphorus, potassium, vitamin B and C.

Area, Production and Yield of POTATO

Globally, Potato is one of the main human alimentary resources. It was the sixth alimentary product in the world after sugar cane, maze, rice and paddy. Potato is a commonly used vegetable, in the country. With production of 40-42 million tonnes, India is the third largest producer of the crop, globally. Although India's yield levels are lower than the crop yield per hectare, in Germany and Netherlands, they are higher than in China and Russia, and the global average, the first three being yield of USA (44.3MT/ha), Netherland (43.6 MT/ha) and Germany (40.0MT/ha). According to the agriculture outlook and situation analysis, reports quarterly agricultural outlook report April-June 2012, potato is cultivated throughout the world, but it is mainly concentrated in countries like China, France, Germany, India, Netherlands, Spain, Poland and USA. Through the cultivation of potato spread, throughout the country, the top 10 potato producing states in the country account for about 97 percent, of production covering 90 percent of total crop area. Out of these states, the bulk production is concentrated in Uttar Pradesh, West Bengal and Bihar account for about 78 percent of India's total potato production. UP has a share of 33.12 percent of India's production, followed by West Bengal (31.4) percent and Bihar (13.56). In terms of yield West Bengal tops the list with 32.96 MT per hectare, followed by U.P., with 24.88 MT and Bihar, 18.41 MT per hectare. Potato is harvested mainly, between October to December, and January to April. There is a gap of about four months: May to August, when no harvesting is done in any of these states, requiring cold storage facilities. Among the common improved potato varieties grown in India, Kufri Chandramukhi (large, Oval, White), kufriJyoti (large, Oval, white), kufriLalima (medium, round, red) is commonly grown in Uttar Pradesh.

Commercially available tractor mounted elevator digger, provide with elliptical agitator is used almost universally, by potato growers in harvesting potato. Though this machine reduces the operating time and labor required, it deteriorates the quality of potato, because of the high percentage of damage. Damage is caused primarily due to the constructional parameters, such as rod spacing, jump sprocket for vertical oscillation, web steepness and due to operational parameters, like conveyor to forward steep ratio, peak acceleration and direction of agitator of elevator web. In the elevator digger, elevator web is agitated vertically with the help of elliptical sprocket to separate the potatoes from the soil, soil clods and stones if any etc. The elliptical sprocket/ jump sprocket help in creating a vertical oscillation of conveyor web, which in turn produce vertical oscillation of soil potato mass and potatoes after separation, damage in tuber occurs. Because of the irregular shape of a potato, many of them impact with rods, side walls and solid colds and jump out of the

conveyor web inserted windrowing them in a row. Potato jumping and damage become excessive, when vertical oscillation is vigor. Extra labor is, therefore, required for manual picking. To rectify this problem of bouncing of tubers on the conveyor, due to irregular shapes, size and structure the adjustable elevator is made, at which we can adjust the angle of the elevator to a required distinct. The roller which passes through the dugged surface, it makes the irregular surface to level surface, where the tubers falls back off the digger on the level surface, passing through the conveyor. The project work has been undertaken to study the following

OBJECTIVES

- Development of adjustable elevator for tractor drawn potato digger.
- To evaluate performance of tractor drawn potato digger cum elevator.

MATERIALS AND METHODS

The present research "Development of adjustable elevator for tractor drawn potato digger" was carried out in agronomic conditions of Allahabad (U. P.). All the trails were carried out, at the same time in different plots.

The constructional and functional details of the machine and procedure, followed for the field testing and measurements are described below:

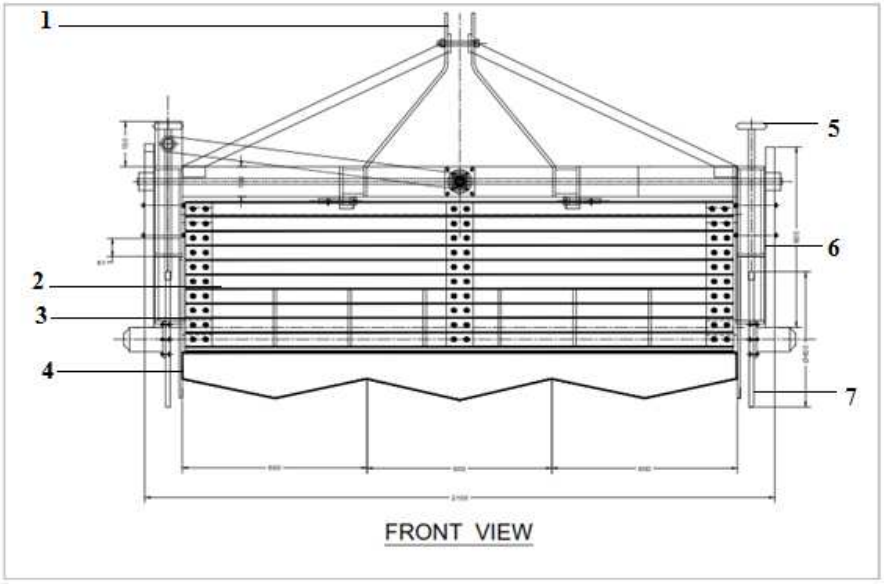
- Construction and working principle of machine
- Field condition and operation of machine
- Measurement of performance parameters

Working Principle

As the machine moved forward, the V shaped blades split the ridges and the potatoes were dug out, and thrown on the elevator. The disc attached helped in throwing the potatoes on the elevator. The elevator further transported these potatoes to the rear end of the elevator. While digging the potatoes, soil clods came along with these potatoes. These soil clods got broken and dropped, due to the spacing provided, between the rods in the elevator. The potatoes were easily picked up by the manual labors.

Field Condition

The performance evaluation of the implement was done in karma village, Allahabad (U.P). The shape of the field for trial was rectangular, having an area of about 90×20.3m². Planting of potatoes in this field was done, with planter. The height of the ridges was 15cm and the spacing between the rows was 60cm. Field tests were conducted in the month of February - March 2017. The soil moisture was 11.08% on dry basis, which was adequate for digging operation as the soil did not stick to the potatoes. The variety of potato for which trial was conducted, was Badshakopri.



1. Three Point Linkage 2. Chain Elevator 3. Oscillating Rod4.V Shaped Blade

5. Adjustable Elevator Shaft 6. V Belt 7. Disc

Figure 3.1: Front View of Potato Digger Cum Elevator

Figure 3.2: Working Condition of Potato Digger

Operation of the Machine

The potato crop was ready for harvesting after 120 days of planting. The harvesting operation was carried into the month of February -march 2017, by potato digger cum elevator machine, mounted on M&M tractor. The test procedures are as follows:

- First of all the, dimensions of the field, where the test was to be conducted were measured and the area was calculated. The length was 90m and the breadth was 20.3m. The area of the rectangular field was found to be sq-

m.

- The height of the ridges and row to row spacing was measured before harvesting operation. The height of the ridges was 15cm and the spacing between the rows was 60cm.
- Three trails were carried out along the length. The depth of cut was fixed it was 15cm.
- Before harvesting operation the fuel tank of the tractor was topped up to the brim.
- The amounts of exposed potatoes were picked up manually, and their weight was recorded. Later on the potatoes, which remained unexposed were dug with the help of khurpi and weighed. From the total amount of potatoes cut and bruised, potatoes were separated and weighed properly.
- The digging of the potatoes by the implement was done to evaluate the amount of exposed potatoes. Machine was designed as such to avoid covering the potatoes with soil. Circuitous pattern of machine operation was adopted. In this operation, alternate pairs of ridges were dug living beside the adjacent pair. This pattern was adopted to avoid the turning losses in the field.
- The height of the elevator was kept at 35, 40, 45 and 50cm, respectively, the trails were done to evaluate the different heights of the elevator, where there is no bouncing of tubers on the elevator, due to difference in size and shape.
- The total time recorded for harvesting operation was recorded, with the help of a stopwatch and subsequently fuel consumption, in liters per hour was calculated, by subtracting the amount of fuel left in the tank from the initial amount of fuel taken.

Parameters under Study

Some parameters were taken to evaluate the performance of the digger. There were mainly two types of parameters under which all the factors were considered which are given below:

Independent Variable

The independent variables were those variables which were controlled by the operator. The independent variables which were taken are given below:

- Elevator height: 35, 40, 45 and 50cm.
- Depth of cut: 15cm
- Speed:3kmph

Dependent Variables

Dependent variables were those variables whose values were dependent on the independent variables. The dependent variables which were taken are given below

- Digging efficiency in percent
- Bruising in percent

- Damage percentage
- Fuel consumption in l/h
- Field capacity
- Slippage percentage

Speed

Assume two points A and B vertically, in the center of the field at a distance of 10 meters. When the tractor was in motion and its exhaust pipe came in line with the Point A, the stop watch was started. At the other end again, when exhaust pipe was in line with the point B, the stopwatch was stopped. The readings were taken five times, five times in each direction of travel. The readings of the time taken were averaged and the speed of operation was calculated as given below:

$$\text{Speed (km/h)} = \frac{Distance(m)\times 60\times 60}{Time(sec)\times 1000}$$

Depth of Cutting

The heights of ten ridges were measured randomly, before the operation of the machine. The average height of the ridges was calculated from these readings. After the operation of the machine, the remaining height was measured at different places. The difference gave the depth of cut of the machine.

(Depth of Cut = Height of the Ridge – Height after Cut)

Elevator Height

The elevator height is adjusted, with the help of adjustable shafts on both sides of the implement; it is based on the bouncing of tubers on the elevator due to variance in size, shape and structure. The height is changed to 35, 40, 45 and 50cm, respectively. The elevator height at which there is no damage, no bruising loss, no bouncing of tubers on the elevator is found.

Measurement of Moisture Content of Soil

The soil sample was collected from the field and the soil moisture was measured, by the oven dry method. The soil was dried in the oven, and the moisture content after and before, was compared. The sample was kept at 105˚c for 24h.

$$\text{Moisture content (\%)} = \frac{\text{initial weight of soil} - \text{final weight for soil}}{\text{Intial weight}} \times 100$$

RESULTS AND DISCUSSIONS

This chapter deals with the discussion of the results of field investigation, carried out on the experimental adjustable elevator, for tractor drawn potato digger.

The experiment on “Development of adjustable elevator for tractor drawn potato digger” was carried out, during the month of February – March, 2017 at karma village, Allahabad. Harvesting of potato with tractor drawn potato digger cum elevator, is done in three trails as discussed in the following heads.

General Observation

The potato digger cum elevator is working better at an elevated height of 40cm. At the elevator height of 40cm, it

was observed that, there is no bouncing of tubers on the elevator while digging, and the damage, loss, bruising loss and cutting loss was less, and the digging efficiency is more.

Quality of Potato Tubers

The digger was found to perform very well, under varying soil condition. Very little mechanical injury of the tubers was observed, in these cuts tubers and skinned tubers. The percentage of cut tubers damages, were based on the total weight and no. of the tubers, in each sample. It is evident that, with the increase in forward speed, the skinning damage also increases up to 4%. On studying the average percentage of slightly to severely damaged tubers, was 1.8%. This is considerably lower than the damage level of the commercial harvesters. It results in 4-5 reduction in harvesting losses.

Performance of Potato Digger Cum Elevator

Tractor drawn potato digger cum elevator is suitable for digging and exposing tubers. It saves 75% labor and operating time, and 50% on the cost of operation compared to conventional method of manual digging, with spades or by two row potato digger, as shown in Table 4.1. The forward speed of the digger can vary up to 3km/hr. This is highly recommended to the potato grower, and to custom hire service.

Moisture Content Measurements for Different Plots of the Field

Moisture content has been measured for the different plots of the field, by the oven dry method with the help of core cutter and oven. Three samples of soil, for each trail plot were taken for moisture measurement and measured at dry basis. The corresponding values of moisture content % (db), was 11.79, 11.67 and 9.79 in trail plots I,II,III, respectively. The average value of moisture content % of the field was 11.08.

Table 4.1: Moisture Content for Different Trail Plots in the Field

Sr. No	Samples	Moisture content % (db)
1.	I	11.79
2.	II	11.67
3.	III	9.79
Average		**11.08**

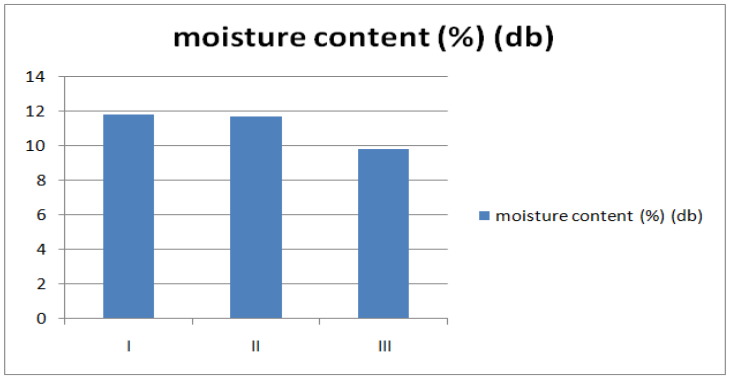


Figure 4.1: Moisture Content (%) (db)

Table 4.2: Summary of Performance of a Tractor Drawn Potato Digger Cum Elevator

Sr. No	Unit Operation	Tractor Drawn Potato Digger Cum Elevator		
		Trail 1	Trail 2	Trail 3
1.	Digging efficiency (%)	89.28	95.77	97.40

2.	Damage percent (%)	0	3.24	0
Table 4.2: Contd.,				
3.	Bruising percent (%)	0	0	0
4.	Depth of digging (cm)	15	15	15
5.	Actual field capacity (ha/h)	0.51	0.33	0.40
6.	Field efficiency (%)	94.44	61.11	74.07
7.	Slippage percent (%)	22.22	46.66	36.36
8.	Moisture content (db)(%)	11.79	11.67	9.79

Table 4.3: Test Result of the Elevator Height Adjustment of Potato Digger

Sr. No	Elevator Height (cm)	Observation
1.	35	Tubers were damaged
2.	40	Working was good, there was no bouncing of tubers on the elevator, no damage, no bruising of tubers
3.	45	By increasing in the height the load increased and slippage was more
4.	50	At this height the clods were dugged from more depth, slippage was more, cutting loss was also more

From the above table it was observed that at an elevated height of 40cm the implement is working more efficient rather than at other heights. It was found that there was no damage, loss, bruising loss, cutting loss and also there was no bouncing of the tubers on the elevator while digging.

Table 4.5: Test Result of Tractor Drawn Potato Digger cum Elevator

Suitable for	Potato
Actual field capacity	0.30-0.40 ha/h
Digging efficiency	94-96%
Bruising of tubers	0%
Damage	1.08%
Slippage	35.18%
Field efficiency	76.54%
Harvesting cost	1450 (Rs/ha)

SUMMARY AND CONCLUSIONS

Potato is a vegetable crop of both sub-tropical and temperate region of the country. It occupies the largest area under any single vegetable crop in the world, and produces more food content per unit area, than cereals in short span of time. Potato harvesting is a time consuming operation, due to its various activities taken place at the same time. The harvesting, collection, bagging and transportation to the cold storage/ store operations are done, simultaneously. Traditionally, potato is harvested with khurpi/ spade/ kudali, and is considered to be labor intensive and time consuming process.

These operations require about, 210 man-day per hectare, when the crop is harvested manually with spade, khurpi or kudali. The field also becomes undulated, when the potato is harvested manually and requires 2-3 weeks for ploughing, for the next crop. The cost of production of potato becomes very high, because of labor charges and also harvesting.

Commercially available tractor mounted potato digger cum elevator, are common with farmers having 10 ha or more land. Potato damages like cut, bruise, split, etc. are of the order 10-12 percent, in elevator diggers. Two pairs of elliptical sprockets, that cause separation of potatoes from the soil, soil clods and foreign material, if any, are responsible for the damage. Therefore, it was felt essential to estimate the extent and type of damage, and soil potato separation, by the potato elevator digger.

A potato digger cum elevator was designed and constructed, which is capable of diggings potato with a minimum injury, working on the principle of digging and elevating the soil and potatoes, simultaneously. The digger, which is equipped with hydraulic drive, was found to be very flexible and could accommodate variable conditions.

Tractor drawn potato digger is suitable for digging and exposing tubers. It saves 75 percent labor and operating time and 50 percent cost of operation, compared to conventional method of manual digging with spades, or by cultivators. It also resulted in 4-5% reduction, in harvesting losses.

The Following Conclusions May be Drawn on the Field Trial of Tractor Drawn Potato Digger Cum Elevator:

- The potato digger cum elevator exposed 94-96% of potatoes, in a single pass.
- The tractor drawn potato digger cum elevator, was found highly economical, time saving, reducing labor dependency, with minimum damage. This is highly recommended to the potato growers and to the customary high services.
- The use of potato digger cum elevator is advantageous, for harvesting potatoes in terms of cheapness, labor saving, saving in operational time and fuel (diesel) consumption, on area basis. The total operational time and diesel consumption per unit area basis, by minimum in case it saves 75 percent labor and operating time, and 50 percent cost of operation, compared to conventional method of manual digging with spades or by cultivators.
- It was observed that, at an elevated height of 40cm, the implement is working more efficient rather than at another height. It was found that, there was no damage, loss, bruising loss, cutting loss and also there was no bouncing of the tubers, on the elevator while digging.
- The potato damage is about 1-2%, by use of digger cum elevator, is comparatively lesser than by use of deshi plough and manual digging by spade and khurpi. It results in 4-5% reduction in harvesting losses.
- The percentage of potato digger elevator does not require additional vertical force.
- The hourly cost of operation of tractor, with tractor drawn potato digger cum elevator, was comparatively higher than the other potato harvesting equipment. However, the cost of operation on area basis was minimized
- The effective field capacity of the machine was 0.40 ha/hr.

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